09/18/00 Jc869 U.S. PTO

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PTO/SB/05 (2/98)
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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	2453-80A
First Inventor or Application Identifier	H. Kenneth Staffin
Title	"Fluidized Bed Gas Distributor System..."
Express Mail Label No.	EK052282770US

Jc675 U.S. PTO 09/663995 09/18/00

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231

1. [✓] * Fee Transmittal Form (e.g., PTO/SB/17) (Submit an original and a duplicate for fee processing)
2. [✓] Specification [Total Pages 21] (preferred arrangement set forth below)
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (if filed)
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [✓] Drawing(s) (35 U.S.C. 113) [Total Sheets 8]
4. Oath or Declaration [Total Pages 3]
   a. [✓] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) (for continuation/divisional with Box 17 completed) [Note Box 5 below]
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).
5. [ ] Incorporation By Reference (useable if Box 4b is checked) The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered to be part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. [ ] Microfiche Computer Program (Appendix)
7. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. [✓] Assignment Papers (cover sheet & document(s))
9. [ ] 37 C.F.R.§3.73(b) Statement (when there is an assignee) [ ] Power of Attorney
10. [ ] English Translation Document (if applicable)
11. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
12. [ ] Preliminary Amendment
13. [✓] Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
14. [✓] *Small Entity Statement(s) (PTO/SB/09-12) [ ] Statement filed in prior application, Status still proper and desired
15. [ ] Certified Copy of Priority Document(s) (if foreign priority is claimed)
16. [ ] Other: ....

*NOTE FOR ITEMS 1 & 14: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

17. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:
[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: ______/______
Prior application information: Examiner ______________ Group / Art Unit: ______________

18. CORRESPONDENCE ADDRESS

[ ] Customer Number or Bar Code Label (Insert Customer No. or Attach bar code label here) or [✓] Correspondence address below

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Name (Print/Type)	Ronald R. Santucci	Registration No. (Attorney/Agent)	28,988
Signature	Ronald R. Santucci	Date	09/18/00

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FEE TRANSMITTAL

Patent fees are subject to annual revision on October 1.
These are the fees effective October 1, 1997.
Small Entity payments must be supported by a small entity statement, otherwise large entity fees must be paid. See Forms PTO/SB/09-12. See 37 C.F.R. §§ 1.27 and 1.28.

TOTAL AMOUNT OF PAYMENT ($) 385.00

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	H. Kenneth Staffin
Examiner Name	
Group / Art Unit	
Attorney Docket No.	2453-80A

METHOD OF PAYMENT (check one)

1. [x] The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number: Pitney, Hardin ...

Deposit Account Name: 50-1145 (Order No. 2453-80A)

[x] Charge Any Additional Fee Required Under 37 C.F.R. §§ 1.16 and 1.17

[ ] Charge the Issue Fee Set in 37 C.F.R. § 1.18 at the Mailing of the Notice of Allowance

2. [x] Payment Enclosed: Charge Dept. Acct.
[ ] Check [ ] Money Order [x] Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	790	201	395	Utility filing fee	345
106	330	206	165	Design filing fee	
107	540	207	270	Plant filing fee	
108	790	208	395	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 345

2. EXTRA CLAIM FEES

			Extra Claims		Fee from below		Fee Paid
Total Claims	11	-20** =	0	X		=	0
Independent Claims	1	- 3** =	0	X		=	0
Multiple Dependent						=	0

***or number previously paid, if greater; For Reissues, see below*

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	22	203	11	Claims in excess of 20
102	82	202	41	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim, if not paid
109	82	209	41	** Reissue independent claims over original patent
110	22	210	11	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	950	217	475	Extension for reply within third month	
118	1,510	218	755	Extension for reply within fourth month	
128	2,060	228	1,030	Extension for reply within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,320	241	660	Petition to revive - unintentional	
142	1,320	242	660	Utility issue fee (or reissue)	
143	450	243	225	Design issue fee	
144	670	244	335	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	40
146	790	246	395	Filing a submission after final rejection (37 CFR 1.129(a))	
149	790	249	395	For each additional invention to be examined (37 CFR 1.129(b))	

Other fee (specify) ______

Other fee (specify) ______

* Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 40

SUBMITTED BY				Complete (if applicable)	
Typed or Printed Name	Ronald R. Santucci			Reg. Number	28,988
Signature	[signature]	Date	09/18/00	Deposit Account User ID	

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Express Mail No. EK052282770US

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) AND 1.27 (c)) - SMALL BUSINESS CONCERN			Docket No. 2453-80A
Serial No.	Filing Date herewith	Patent No.	Issue Date

Applicant/ Patentee: **H. Kenneth Staffin, Edward P. Traina and Giovanni Rubino**

Invention: **FLUIDIZED BED GAS DISTRIBUTOR SYSTEM FOR ELEVATED TEMPERATURE OPERATION"**

I hereby declare that I am:

- ☐ the owner of the small business concern identified below:
- ☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: **Procedyne Corp.**
ADDRESS OF CONCERN: **11 Industrial Drive, New Brunswick, New Jersey 08901**

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the above identified invention described in:

- ☒ the specification filed herewith with title as listed above.
- ☐ the application identified above.
- ☐ the patent identified above.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed on the next page and no rights to the invention are held by any person, other than the inventor, who could not qualify as an independent inventor under 37 CFR 1.9(c) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

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Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

☒ no such person, concern or organization exists.
☐ each such person, concern or organization is listed below.

FULL NAME ______________________
ADDRESS ______________________
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME ______________________
ADDRESS ______________________
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME ______________________
ADDRESS ______________________
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME ______________________
ADDRESS ______________________
☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING: H. KENNETH STAFFIN

TITLE OF PERSON SIGNING OTHER THAN OWNER: President

ADDRESS OF PERSON SIGNING: **11 Industrial Drive**
New Brunswick, New Jersey 08901

SIGNATURE: H. Kenneth Staffin DATE: September 1, 2000

FLUIDIZED BED GAS DISTRIBUTOR SYSTEM FOR ELEVATED TEMPERATURE OPERATION

FIELD OF THE INVENTION

The present invention relates generally to the methods and apparatus for the debonding and sand core removal of sand cores from cast parts, the heat treating of metal parts and the removal of organic contamination from metal parts, and relates more specifically to an improved method and apparatus utilizing a fluid bed furnace equipped with an improved fluidizing gas distributor.

BACKGROUND OF THE INVENTION

In the casting of ferrous and non ferrous metal into parts, the cast part is formed by pouring the molten ferrous or non ferrous metal into a mold. When the part has internal openings or paths, sand cores are made using foundry sand and a binder to the shape of the internal openings or paths, and are positioned in the proper location in the mold. The molten metal is poured into the volume between the mold and the core(s) usually surrounding some or most of the core. When the metal solidifies, the mold is opened and the part is removed. In most cases, the core(s) remain in the interior regions its presence has formed and must be removed.

U.S. Patent No. 5,423,370, the disclosure of which is incorporated herein by reference, describes the invention of a fluid bed furnace for the removal of sand cores from castings, employing a thermal process based on the use of fluidized sand of the same type as used to make the sand core. This same patent describes the use of the fluid bed furnace for the heat treating of the aluminum castings.

In the case of ferrous and non ferrous metal parts formed by other methods than casting, the fluid bed has been established as an important processing approach for the heat treating and cleaning of parts and other objects in significant commercial applications. This is exemplified by U.S. Patent Nos. 4,512,821; 4,524,957; and, 4,547,228, the disclosures of which are incorporated herein by reference.

There are a number of known techniques to provide energy input to a fluid bed furnace to achieve the required temperature level of the fluidized solids bed and meet the energy requirement of the specific process being performed, plus the heat losses of the system. The source of energy input to a fluid bed furnace system is typically electricity or fuel such as natural gas or oil.

The mechanism of transferring the energy from an energy source to the fluidized solids bed is typically accomplished by one or a combination of the following methods:

Mechanism i: Heating the fluidizing gas phase before entering the furnace to a temperature above the operating temperature of the fluidized solids bed, as shown in Figure 1. When the high temperature fluidizing gas enters the fluid bed through the fluidizing gas distribution tuyeres, it provides the required energy input. This is termed "direct heating".

Mechanism ii: Transferring energy through heat transfer surfaces in contact with the fluidized solids bed, typically through heating tubes submerged in the fluidized solids bed, or through the walls of the vessel housing the fluidized

solids bed from a heating mantle surrounding the walls, as shown in Figure 2. This mechanism of energy input is termed "indirect heating".

Mechanism iii: Direct injection of fuel into the fluidized solids bed in gaseous, liquid or solids form and combusting the fuel while it is within the fluidized solids bed; *i.e.*, below the top level of the fluidized solids bed, as shown in Figure 3.

The choice of energy source, is typically economically driven. The choice of mechanism of energy transfer to the fluid bed typically depends upon the geometric configuration of the furnace and the characteristics of the process application involved. This choice is typically determined by the gas phase environment required by the submerged parts.

In applications where the products being process cannot be contacted by products of combustion of typical fuels, the mechanism of transferring energy to the fluid bed must be limited to indirect heating of the fluid bed by *Mechanism ii*, and/or indirect heating of the fluidizing gas to elevate its temperature followed by direct heating of the fluid bed by *Mechanism i* .

In these cases, direct injection of fuel into the fluidized solids bed by *Mechanism iii*, cannot be employed due to combustion gases being present in the fluidized solids bed which has an adverse effect on the quality of the products.

In cases where the combustion products of the typical fuels can contact the parts without quality degradation, and the operating temperature of the fluidized solids in the furnace is higher than the ignition temperature of the fuel, so there is no

concern about ensuring complete combustion of the fuel in the fluidized bed of solids, economical considerations generally favor *Mechanism iii*, above as shown in Figure 3. In Figure 3, the unit is shown equipped with both direct fuel injection and direct combustion air injection. In situations where the fluidizing gas is air, which is the case in many important commercial applications, the direct injection of combustion air is not required because the fluidizing air provides the necessary oxygen for combustion. It is only necessary to feed the fuel to the fluidized bed.

In most cases involving heat treating of metal parts, it is required to maintain careful control of the composition of the fluidizing gas. This requirement typically eliminates *Mechanism iii*, above from consideration for these applications.

For the very important application to sand core debonding of aluminum castings and heat treating aluminum castings and other aluminum parts, the processes take place at approximately 550°C. This temperature is below the ignition point of natural gas and other fuels so the use of *Mechanism iii*, is frequently eliminated based on safety concerns and/or the costs involved in protection devices to practice *Mechanism iii*, safely.

This typically limits consideration to *Mechanisms i* and *ii*, above for the important commercial applications involving processing of aluminum castings and other aluminum parts and heat treating of metals.

Mechanism i, is generally the lower cost approach to providing the required energy to the fluidized solids bed using a fluidizing gas heater to elevate the temperature of the fluidizing gas.

The maximum rate of energy transfer to the gas fluidized solids bed possible by this mechanism, is limited by the maximum temperature the furnace fluidizing gas distribution tuyere system can withstand mechanically, and the maximum fluidizing velocity that can be applied to the solids being fluidized without excessive entrainment of solids in the fluidizing gas exiting from the furnace.

The temperature of the fluidizing gas is typically elevated using a gas heater, and then feeding the high temperature fluidizing gas through the distribution tuyeres of the bed, as shown in Figure 1. The fluidizing gas heater can be either direct fuel fired when the products of combustion are acceptable in the gas phase of the fluidized solids, or indirectly heated by fuel or electricity when the application cannot accept products of combustion in the fluidizing gas phase.

The primary disadvantage to the use of *Mechanism i*, is that in applications requiring high rates of energy input to the gas fluidized solids, the temperature of the fluidizing gas must be significantly higher than the temperature of the fluidized solids bed.

This high temperature fluidizing gas elevates the temperature of the fluidized solids in the immediate vicinity of the fluidizing gas discharge tuyeres well above average bed temperature. This high temperature can in some cases, damage the parts being processed if the parts come close to, or contact a tuyere.

As an example, for the case of processing aluminum metal parts, a typical fluid bed furnace might be solution annealing the parts at 500°C in the bed of fluidizing solids with the fluidizing gas temperature at approximately 815°C. If an aluminum part comes in contact or in the close

vicinity of a fluidizing gas tuyere, the part can be melted or seriously distorted. In addition, there are typically small shavings, pieces, or chips of aluminum which fall from the parts being processed which find their way to the bottom of the fluid bed furnace and gradually accumulate over a period of time. When these pieces approach the vicinity of a tuyere, or contact a tuyere, they are usually melted and gradually surround the tuyeres and impede the flow of air.

The improved fluidizing gas distributor of this invention reduces the temperature of the fluidizing gas before it discharges through the tuyeres, thereby eliminating the local high temperature regions in the vicinity of the tuyere and eliminates the problem of melting or distorting the parts in the vicinity of the tuyeres.

This invention is a new improved approach to transferring energy into a fluidized bed and can benefit applications that can or cannot accept products of combustion of the energy source in the fluidization gas phase, and whether or not the temperature of the fluidized solids bed is above or below the ignition temperature of the fuel used as the energy source.

It accomplishes this broad application advantage by combining some of the concepts of *Mechanism i* and *Mechanism ii*, in an innovative arrangement of heating the fluidized solids by indirect heat transfer followed by direct heating by the fluidizing gas discharging from the gas distribution arrangement. This configuration can be particularly favorable for heat treating metal parts, cleaning metal parts, removing sand cores and enclosing molds from castings, but is also advantageous in some fluid bed reactor configurations involving fluid bed furnaces.

SUMMARY OF THE INVENTION

The invention comprises method and apparatus which overcomes the deficiency in typical fluidizing gas distributors when energy is supplied to a high temperature fluid bed furnace or reactor by high temperature fluidizing gas through the fluidizing gas distributor. This improved gas phase distributor involves a piping array which is mounted in the fluidized bed of solids which conveys the high temperature fluidizing gas to the distribution tuyeres spaced in relatively uniform positions at an elevation in the lower portion of the bed of granular solids forming the fluidized solids. The distribution tuyeres are connected to the bottom of the piping array and are contiguous with the pipes forming the array. The tuyeres are discharging the high temperature fluidizing gas in a downward direction causing the fluidized bed phenomenon to initiate at an elevation at or slightly below the point of discharge of the tuyeres.

This configuration ensures that the piping array is at an elevation above the initiation of fluidization, and therefore, in the bed of fluidized solids. This results in significant indirect heat transfer from the fluidizing gas in the distribution piping through the pipe walls of the array into the fluidized bed due to the generally favorable heat transfer behavior of fluidized solids. This indirect heat transfer causes the temperature of the gas phase discharging through the tuyere distributors to be lower than the temperature of the fluidizing gas which was fed to the piping array. This condition yields a more uniform temperature at the lower part of the

fluidized bed in the vicinity of the distribution tuyeres.

This gas phase distribution invention reduces or eliminates the high temperature zones in the vicinity of the distribution tuyeres which can degrade or destroy the parts being treated which are located near the lower portion of the fluid bed furnace and make it impossible to exploit the benefits of a fluid bed furnace with a directly heated energy transfer mechanism involving high temperature fluidizing gas.

This gas phase distribution arrangement has the additional advantage that the downward direction of discharge of the tuyeres reduces the tendency of particles of solids to enter the piping array through the tuyere gas phase discharge holes.

<u>BRIEF DESCRIPTION OF THE DRAWINGS</u>

Figure 1, is a schematic drawing of a typical fluid bed furnace using elevated temperature fluidizing gas as the mechanism of transferring energy into the bed of fluidized solids.

Figure 2, is a schematic drawing of a typical fluid bed furnace using indirect heating as the mechanism of transferring energy into the bed. This figure shows indirect heating using a heating mantle to transfer heat through the wall of the fluid bed containing vessel as well as indirect heating tubes. The former approach is typically used for smaller furnaces when there is sufficient vessel wall area relative to the volume of the fluid bed to transfer the required energy input. The number of heating tubes required depend upon the amount of indirect heat transfer area needed to meet the required heat transfer rate of the process. Figure 2, also shows the optional use of

a fluidizing gas heater to further supplement the heat transfer rate to the bed of fluidized solids.

Figure 3, is a schematic drawing of a typical fluid bed furnace arrangement using direct injection of fuel into the fluidized bed as the mechanism of transferring energy into the bed. In this configuration the fuel is typically gaseous, for example natural gas, or liquid, for example, oil. This furnace is equipped with a distributor plate containing tuyeres.

Figure 4, is a schematic drawing of a typical fluid bed furnace equipped with the improved fluidized bed gas distributor system of this invention for processing parts in typical sand core debonding and heat treating of aluminum castings and other metals.

Figure 5, is a top plan and side view of the improved fluidizing gas distributor.

Figure 6, is a side section and top plan view of a downward discharging tuyere of an improved fluidizing gas distributor.

Figure 7, is a side partially sectional view of the improved fluidizing gas distributor equipped with a direct firing positive displacement burner firing directly into the piping array of the fluidizing gas distributor.

Figure 8, is a side sectional view of the preferred embodiment of the improved fluidizing gas distributor in a large scale aluminum casting sand core debonding application, where the feed of casting is on the basis of a generally repetitive cycle basis.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to the figures where like parts will be similarly numbered, Figure 4, shows a high temperature fluidized bed furnace 10 in one typical

configuration involving the processing of a major metal part. This furnace is equipped with a fluidized bed gas distributor 12. This gas distributor 12 is shown in more detail in Figure 5 and the downward discharging tuyere generally designated 14 is shown in Figure 6.

In this invention, high temperature fluidizing gas is distributed through the furnace 10 in a horizontal plane by a piping array 16 as shown in Figures 4, 5, and 6. With the discharge of the fluidizing gas from the tuyeres 14 located below the distributing piping array 16, the elevation level of initiation of fluidization of the solids is below the piping array 16. Therefore, the piping array 16 has fluidized solids bed 18 all around it, and the heat transfer rate from the piping array 16 to the bed of gas fluidized solids benefits from the typically favorable heat transfer coefficients between heat transfer surfaces in contact with gas fluidized solids and the fluidized solids themselves. Typically in applications involving foundry sands for the particles, the heat transfer coefficients are in the range of 20 to 100 BTU/hr. $ft^2\,°F$.

Referring to Figure 4, the high temperature fluidizing gas 20 enters the piping array 16 through a feed port 22 in the side of the furnace vessel wall 24, and flows to the array of connecting pipes 16 which are continuous with the feed pipe 22. This piping array 16 is shown in Figure 5. Referring to Figure 5, the entry of the high temperature fluidizing gas is through feed port 22. The flow is typically into the main header pipe 26, into the piping array of branches 28, and out through the holes in the downward discharging tuyeres 32. The gas phase then turns in its typical upward direction in the fluidized

bed. Figure 6, shows one embodiment of a downward discharging tuyere 32.

With the high rate of convective heat transfer from the piping array 16 to the fluidized bed of solids 18, the temperature of the fluidizing gas discharging from the tuyeres 32, is lowered from its feed temperature through port 22, to a temperature considerably closer to the fluidized bed temperature.

Thus the energy input to the fluidized solids is divided between that being convectively transferred indirectly from the high temperature gas flowing through the piping array 16 through the pipe wall 34 to the fluidized solids bed, while the remainder of energy transferred into the fluidized solids is achieved by the direct introduction of the fluidizing gas through the tuyeres 32 into the fluidized solids.

By increasing the heat transfer area of the piping array 16, it is possible to reduce the temperature of the fluidizing gas exiting from the tuyeres 32 to a level close enough to fluidized bed temperature to avoid any damage to parts in the vicinity of the tuyere discharge.

In addition, with the tuyeres 32 mounted in a downward direction, it is possible to conveniently fasten a grating or screen to the top of the piping array without disturbing the uniform flow pattern existing from the tuyeres 32 to prevent small parts or pieces of casting material from falling into the vicinity of the tuyere discharge and either blocking the discharge or in the case of lower melting point metal parts like aluminum, from softening or melting from too high a temperature of tuyere discharge.

Preferred embodiments of this invention are shown in Figures 4 and 8, but there are other

arrangements possible to achieve the benefits of this design approach. Figure 4, is more typical of lower volume processing where loads are fed through a feed door 36 typically in the top of the furnace.

Figure 7, shows a preferred embodiment of this invention for the case of parts which can be subjected to fuel combustion gas phase contact without damage to the parts. In this situation, an economical preferred embodiment is to mount a positive displacement burner 38 discharging directly into the gas distribution array, as shown.

Figure 8, is more typical of larger volume processes where parts are fed by conveyor 40 on a repetitive basis through the furnace system.

Referring to Figure 8, there is seen diagrammatically a typical continuous or semi-continuous thermal process for carrying out the method of the invention with respect to sand core removal involving high volume production operations. This is a typical example of an application of the invention. The application can be practiced with other configurations of fluid bed furnace and/or mechanical conveyors.

A fluidized bed furnace 42 is equipped with a continuous conveyor 40, which can be a chain type or any of the conveyors of this general category. The conveyor is conveying baskets or fixtures 44, which are capable of holding the castings 46 and moving them singly or in groups continuously, or cyclically (semi-continuously) through the furnace 42 in a uniform manner and at a linear speed which is adjusted to achieve the required residence time of the parts 46 in the furnace.

The parts enter the furnace, vestibule 48 through a door 50, which can be automatically opened and closed. After door 50 is closed, the following door 52, opens to allow the basket or

fixture 46 to leave the vestibule 48, and enter the furnace volume 54. These feed doors 50 and 52 keep alternately opening and closing as conveyor 40 moves the successive line of baskets or fixtures through the furnace to the discharge vestibule 56.

The parts exit the furnace into the discharge vestibule 56 through door 58.

After the discharging basket or fixture 44 enters the discharge vestibule 56, door 58 closes and door 60 opens to allow the basket or fixture to exit the vestibule 56 and continue to the next processing step for the castings or to an unloading area where the casting 46 is removed from the basket or fixture, if this process only involves sand core debonding. These discharge doors 58 and 60 keep alternately opening and closing as conveyor 40 moves the successive line of baskets or fixtures out of the furnace 42.

Furnace 42, contains a bed of fluidized solids 62, which in the preferred embodiment is fluidized foundry sand of the same composition and size ranges as was used to manufacture the sand cores which are being removed in this furnace. The level of fluidized solids is such so that the declining elevation of conveyor 40, at the feed end, followed by a horizontal level, and then followed by the inclining elevation of conveyor 40, at the discharge end, are such that the baskets or fixtures 44, containing the parts 46, are passed through the bed of fluidized solids at a controlled rate.

The fluidizing air to create the fluidized bed of granular solids is typically ambient air pumped by blower 64, through air heater 66, and through distribution duct 68, which feeds the heated air to the piping array 16, which forms the improved air distribution system which feeds the fluidizing air

to the downward directed tuyeres 32, into the fluidized bed 62, which accomplishes uniform distribution of the air into the fluidized solids thereby levitating the granular particles and creating the fluidized solids phenomenon at an elevation below the distribution piping array.

The heated fluidizing air also provides the required energy to maintain and control the fluidized solids at the temperature required to debond the sand cores by convective heat through the walls 34 of the piping array 16 forming the improved fluidizing air distribution system and subsequently, after its temperature has been reduced by this convective heat transfer, by discharging through the ports or holes 30 of the downward discharging tuyeres 32 directly into the bed of fluidized solids when it gives up additional energy to the fluidized solids as its temperature is reduced to the temperature of the fluidized solids bed.

Thus the temperature of the fluidized solids in the vicinity of the discharge of the discharge of the tuyeres is not as high with this improved fluidizing air distribution system due to the indirect convective heat transfer through the piping array 16, as it would be in the absence of this innovative improvement. With this reduction in fluidizing air temperature exiting from the tuyeres 32, the problem of castings or parts being damaged due to close proximity to the tuyeres is eliminated as well as the problem of pieces of aluminum or other discard pieces of the part which are removed from the casting and fall to the bottom of the furnace where they can be melted by the high temperate fluidizing air discharges from tuyeres.

The temperature and residence time of an aluminum casting in furnace 42 to accomplish the

thermal decomposition of the bonding agent is typically accomplished in the temperature range of 450°C to 550°C with the parts at temperature approximately 20 to 90 minutes depending upon the geometry and size of the parts involved.

The added foundry sand from the sand cores which flows into the fluidized bed is discharged from the furnace by overflowing through overflow pipe 70 and is then collected, cooled, sometimes sieved, and is typically ready for reuse.

The fluidizing gas from the bed of fluidized solids 62 exits the furnace through duct 72, is then passed through an off-gas treatment, system 24, typically comprising a cyclone for particulate removal and an afterburner to oxidize any volatile organic carbon (VOC) compounds from the thermal decomposition of the sand core binding agent and then through an exhauster 76, which maintains the fluidized bed furnace 42 under a slightly negative pressure, typically less than 0.5 inches w.c. and causes the fluidizing gas to exit the furnace system.

When the requirement for sand core debonding is subsequently followed by a solution annealing heat treating step, the same system shown in Figure 2, may be employed for both steps with the exception that fluidized bed furnace 42 must be made sufficiently long to provide for the residence time requirements to accomplish both processing steps.

The following application involving aluminum automotive engine parts was performed in a pilot plant operation which simulated the process of this invention:

Parts: Aluminum castings/Engine blocks

Engine block: 195 Kg each

Sand mold and cores weight: 45 Kg in and surrounding each block

No. of blocks/test: 2

Sand Core Debonding Conditions:	Temperature:	500°C
	Residence Time:	90 minutes
	Environment:	Fluidized Solids/ Foundry Sand
Heat Treating Conditions:	Temperature:	500°C
	Residence Time:	5 hrs.

	This was total time including the 90 minutes of sand core debonding. Both operations were conducted in the same furnace in series.
Quench:	Rapid quench to 200°C in a fluidized solids bed of foundry sand. Fluidized solids cooled using water cooling coils.
Aging:	3 hrs. at 230°C in fluidized bed aging furnace Ambient Air Cooling to 60°C.
Heat Treating results:	Blocks achieved a Brinell Hardness of 93-109.

It should be understood that the preferred embodiments of this process have been disclosed by way of examples, and that other modifications may

occur to those skilled in the art without departing from the scope and split of the appended claims.

What Is Claimed Is:

1. A gas phase distributor in a fluid bed reactor or furnace comprising a gas phase piping array discharging into a fluid bed of granular solids through a plurality of tuyeres which are coupled to and mounted beneath the piping array such that the granular solids are fluidized at a vertical elevation below the piping array thereby causing elevated temperature fluidizing gas to indirectly heat the fluidized bed through the piping array prior to entering the fluidized bed through the tuyeres.

2. The gas phase distributor of claim 1, where the discharge from the piping array is through openings or ports in a bottom portion of the piping array.

3. The gas phase distributor of claim 2 comprising a heat exchanger in a feed line to the gas phase distributor such that the heat exchanger location is above a vertical elevation of fluidizing gas distribution ports and submerged in the fluidized solids, thereby permitting indirect heat transfer from elevated temperature fluidizing gas so as to transfer energy to fluidized solids prior to entering the fluidized bed through the gas distributor ports.

4. The gas phase distributor of claim 1, wherein gaseous fuel is combusted with air to achieve high temperature combustion gas products, which is fed through the piping array in the fluid bed furnace transferring energy through the piping array to the fluid bed furnace thereby lowering the temperature

of the gas discharging through the tuyeres into the fluidized bed.

5. The gas phase distributor of claim 3, wherein gaseous fuel is combusted with air to achieve high temperature combustion gas products, which is fed through the piping array in the fluid bed furnace transferring energy through the piping array to the fluid bed furnace thereby lowering the temperature of the gas discharging through the ports into the fluidized bed.

6. The gas phase distributor of claim 4, where the fuel is a liquid fuel.

7. The gas phase distributor of claim 5, where the fuel is a liquid fuel.

8. The gas phase distributor of claim 1, wherein the discharge direction of the tuyeres initiates fluidization of the granular particles at an elevation below the distribution piping array to ensure the piping array is submerged in fluidized solids which provides for a high heat transfer coefficient from the piping array to the fluidizing solids, thereby reducing the temperature of the fluidizing gas prior to the discharging through the tuyeres.

9. The gas phase distributor of claim 2, wherein the discharge direction of the openings initiates fluidization of the granular particles at an elevation below the distribution piping array to ensure the piping array is submerged in fluidized solids which provides for a high heat transfer coefficient from the piping array to the fluidizing solids, thereby reducing the temperature of the

fluidizing gas prior to discharging through the tuyeres.

10. The gas phase distributor of claim 9, wherein tuyeres convey the fluidizing gas in a downward direction which enhances removal of any materials which enter the tuyeres during periods of shutdowns or low fluidizing gas flow rates.

11. The gas phase distributor of claim 3, wherein the ports convey the fluidizing gas in a downward direction which enhances removal of any materials which enter the ports during periods of shutdowns or low fluidizing gas flow rates.

ABSTRACT

A method and apparatus for the debonding and sand core removal of sand cores from cast parts, the heat treating of metal parts and the removal of organic contamination from metal parts, which is utilizing a fluid bed furnace having an improved fluidizing gas distributor which discharges fluidized gas in a downward direction away from the parts in the fluidized bed.

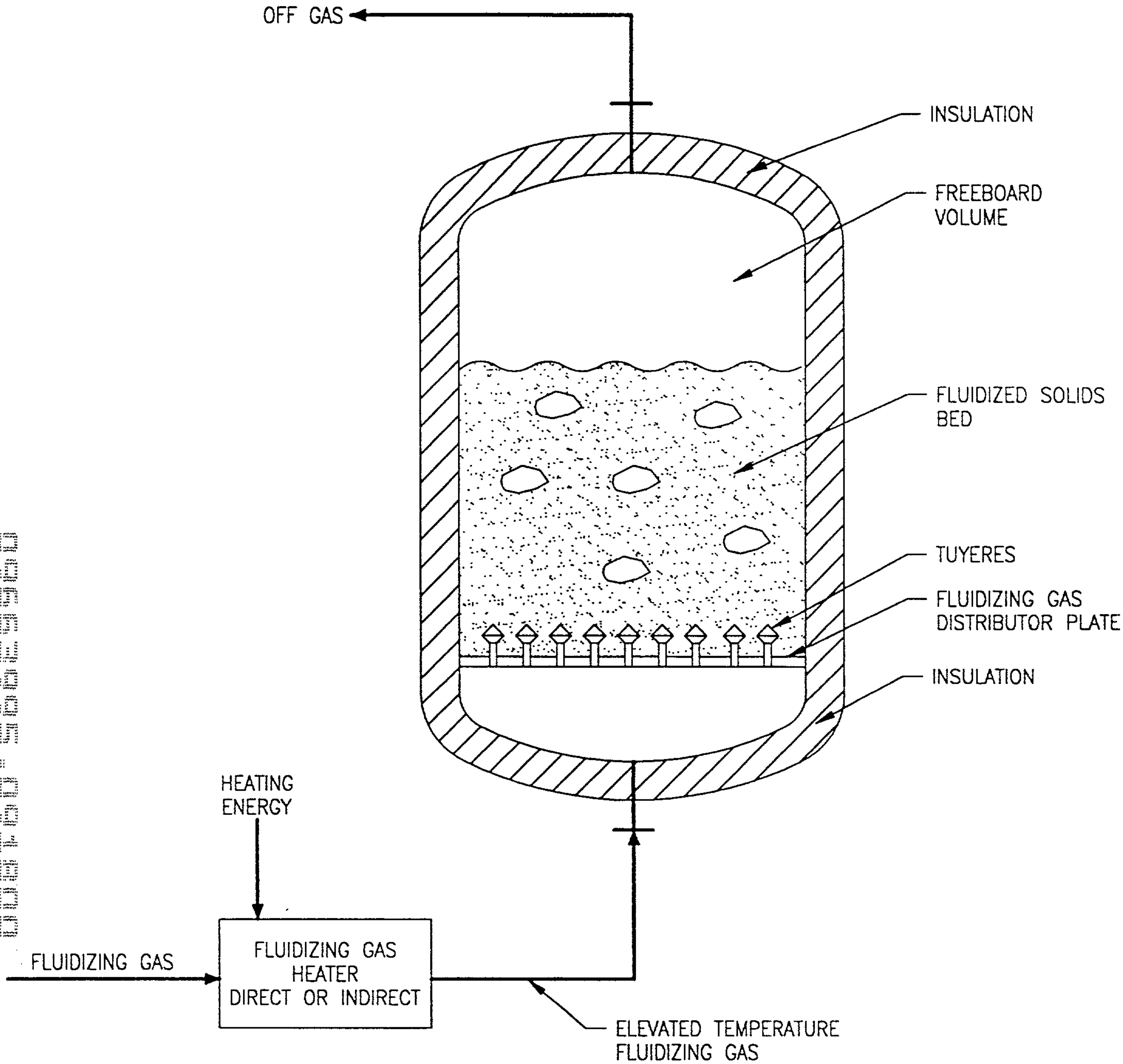

FIGURE 1: FLUID BED FURNACE – HEATING VIA HIGH TEMPERATURE FLUIDIZING GAS

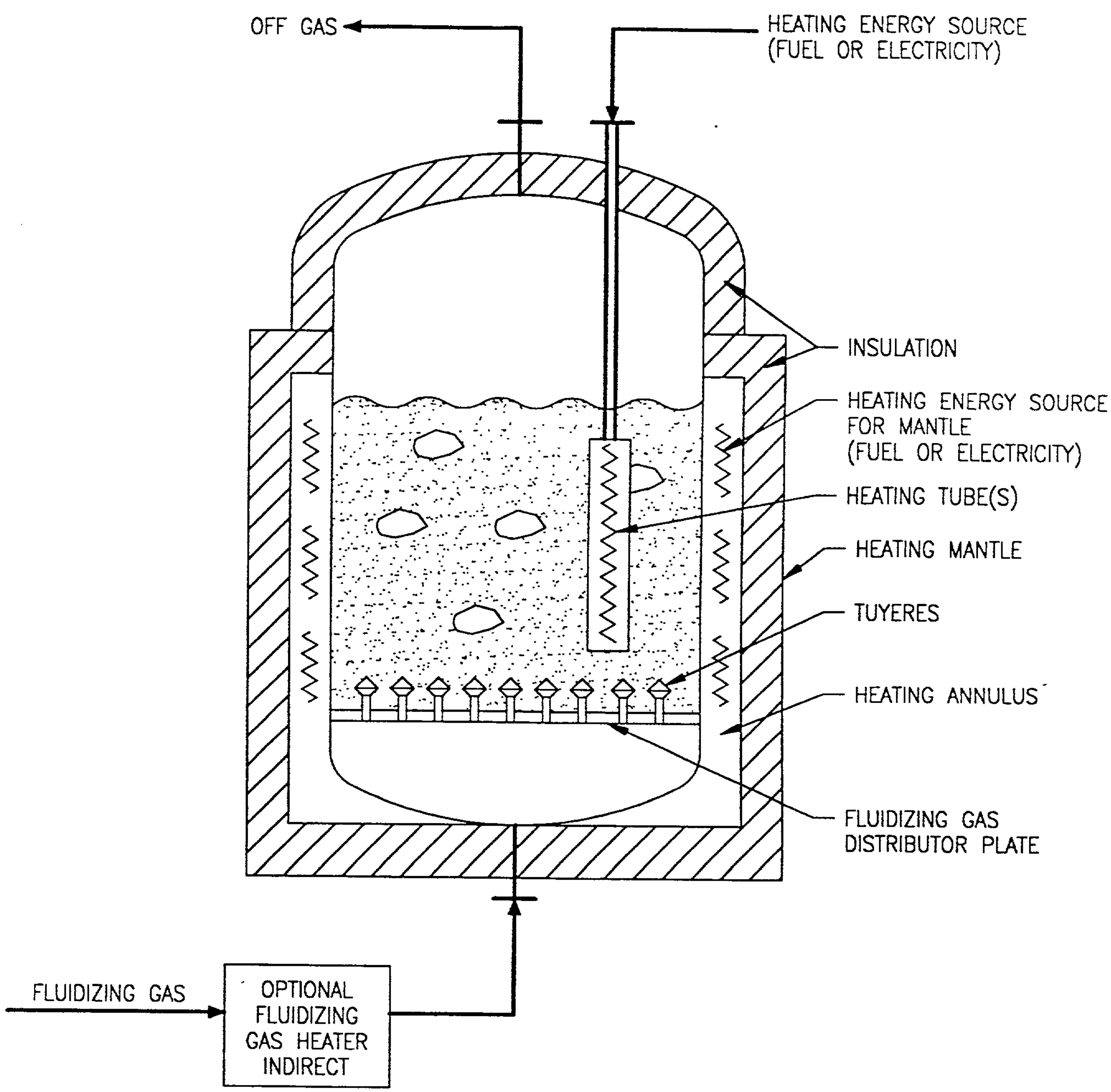

FIGURE 2: FLUID BED FURNACE – INDIRECT HEATING

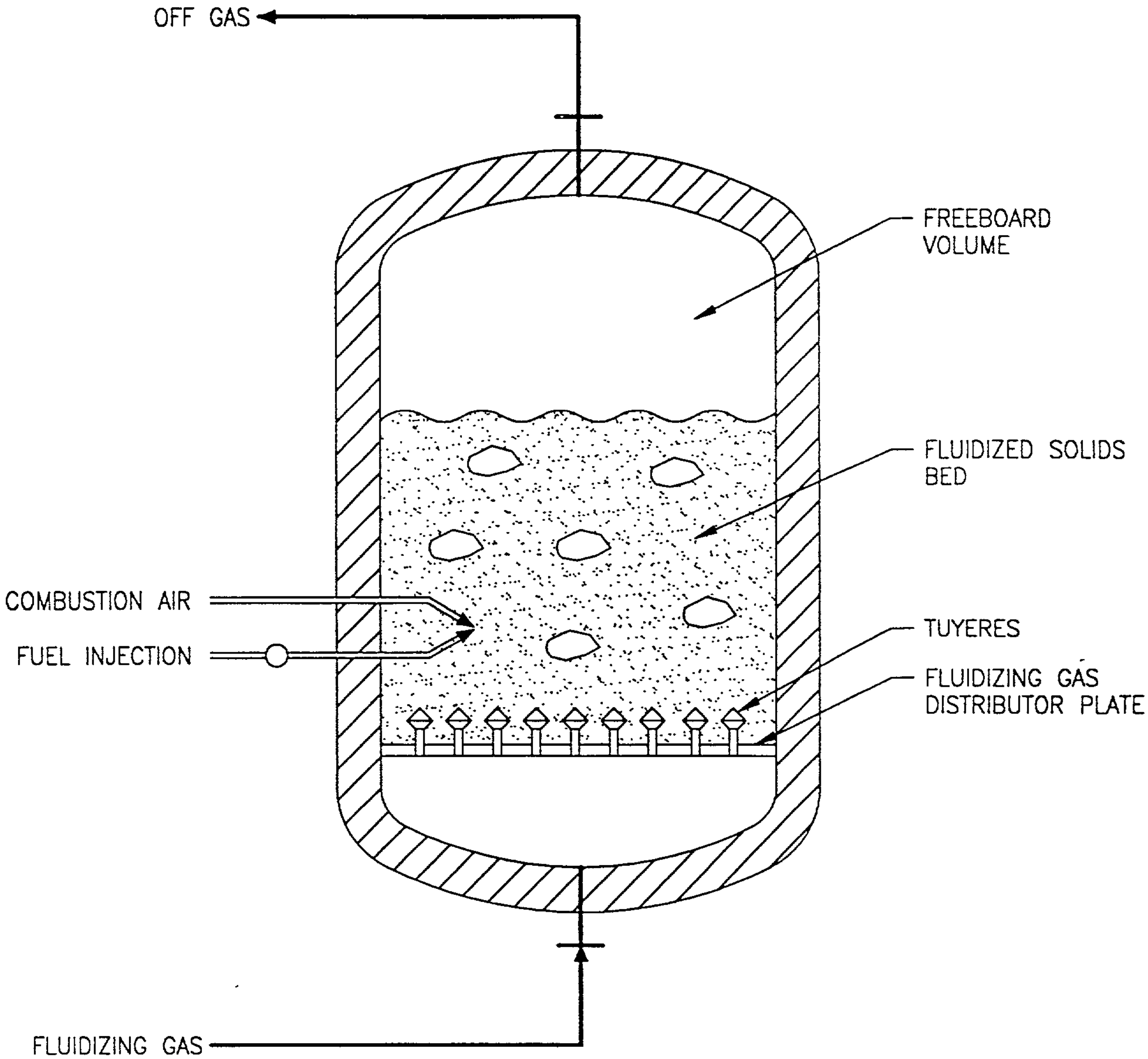

FIGURE 3: FLUID BED FURNACE – DIRECT FUEL INJECTION

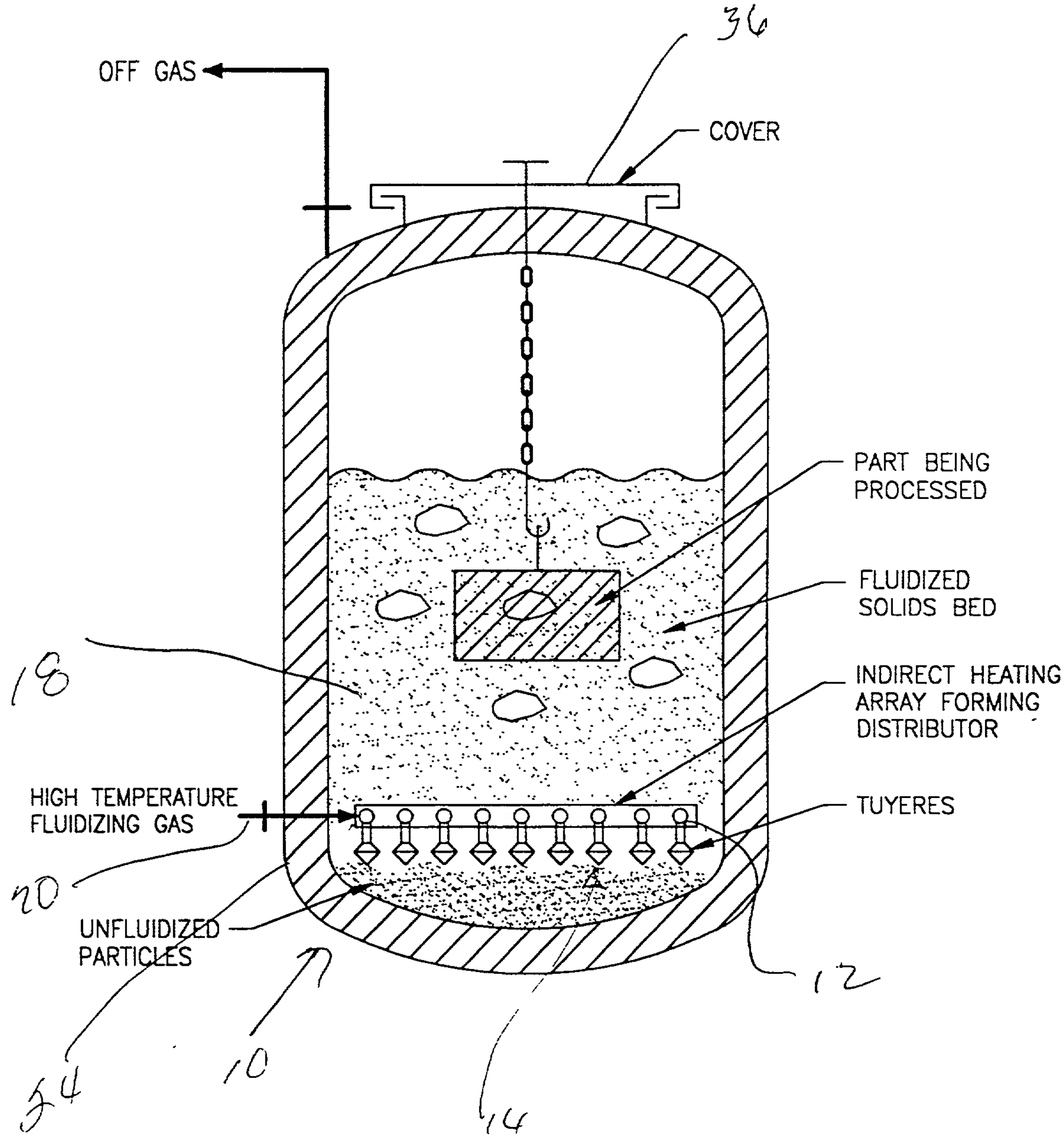

FIGURE 4: IMPROVED FLUIDIZING GAS PHASE DISTRIBUTION SYSTEM

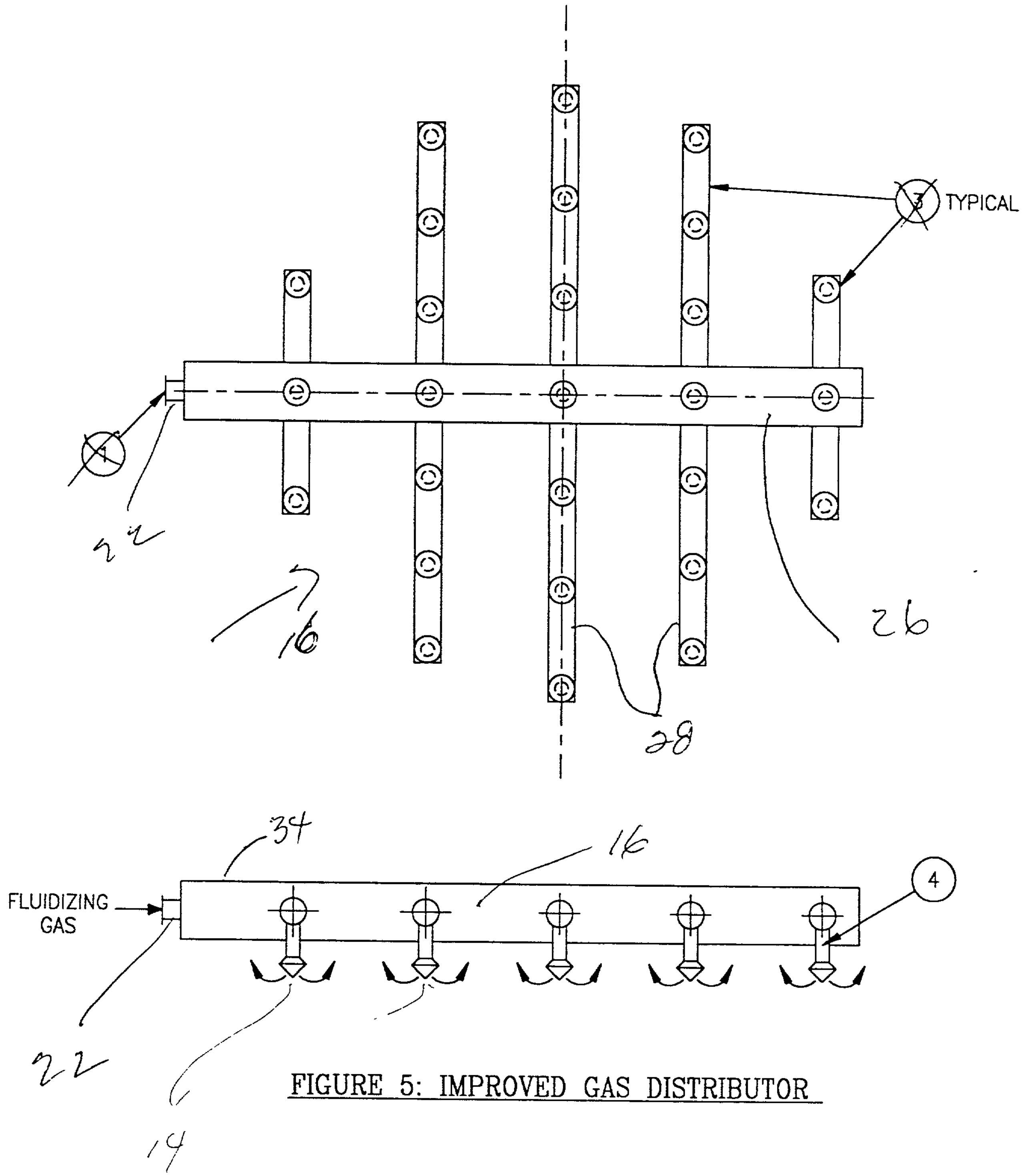

FIGURE 5: IMPROVED GAS DISTRIBUTOR

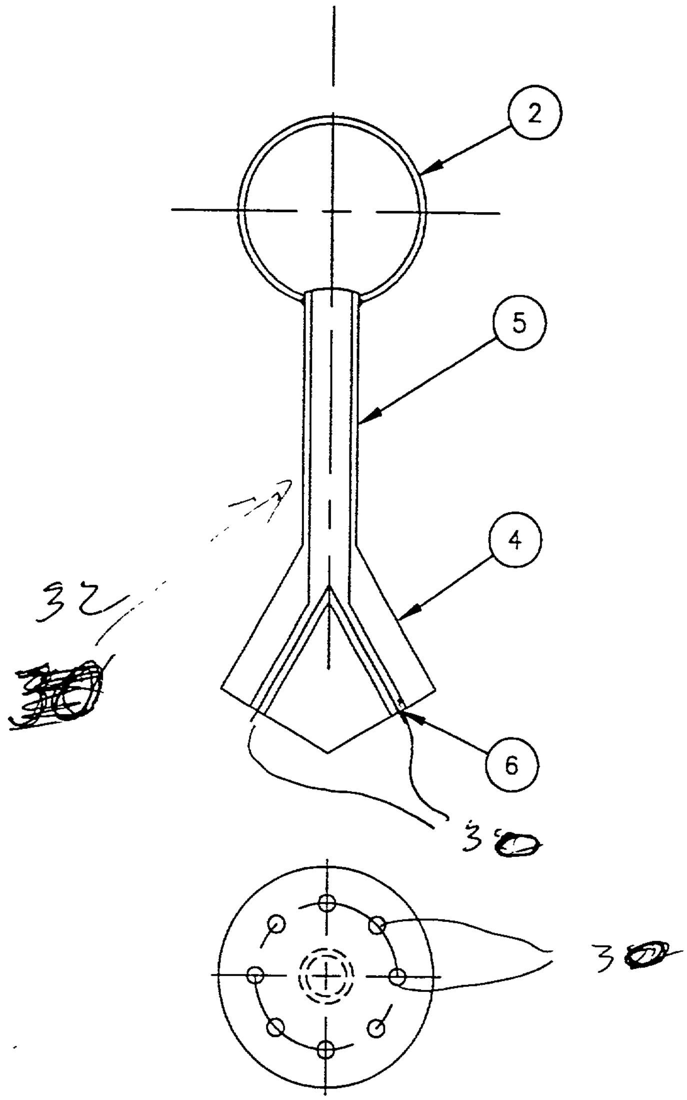

FIGURE 6: TUYERE DISTRIBUTOR

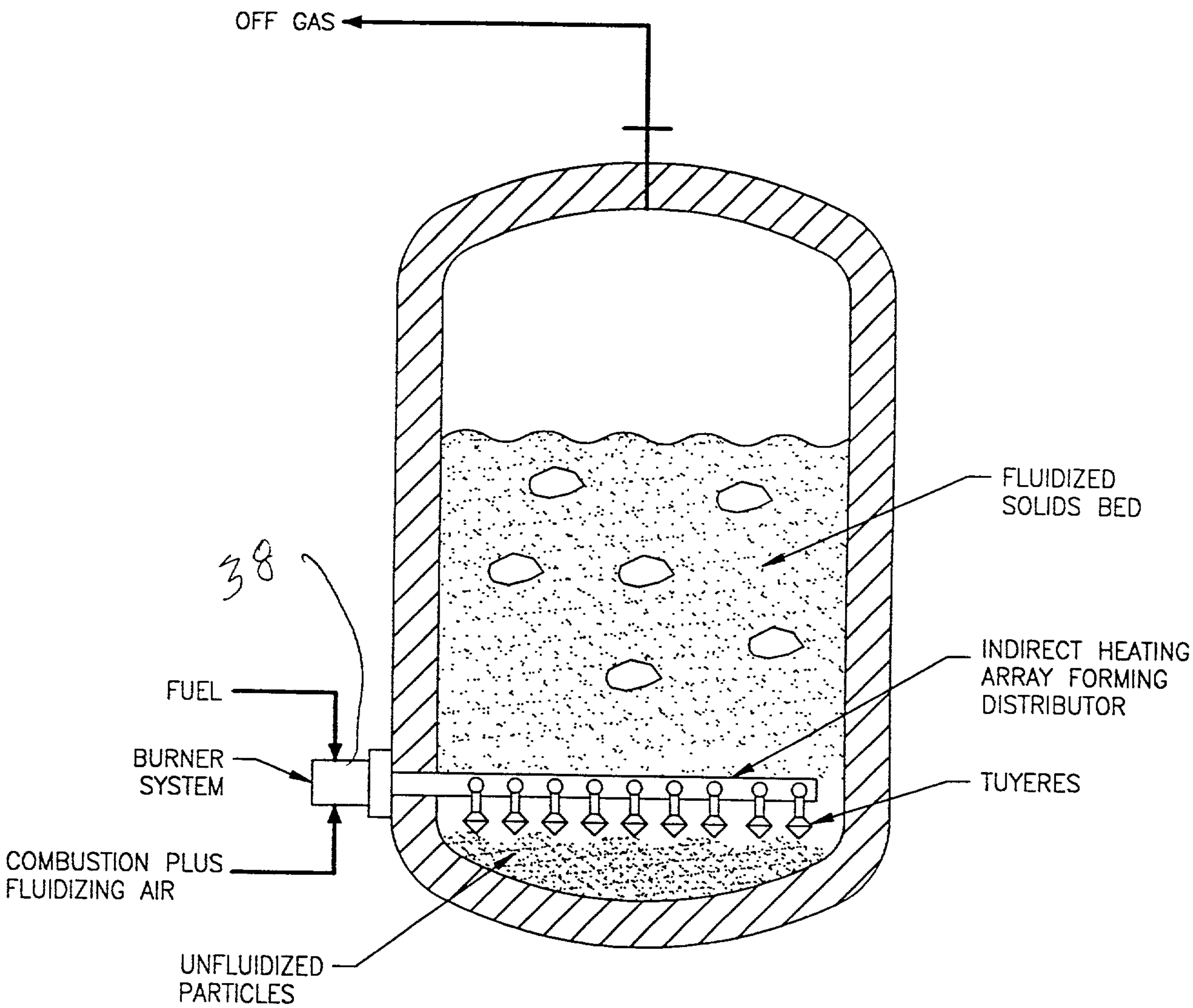

FIGURE 7: BURNER FIRED DISTRIBUTION SYSTEM

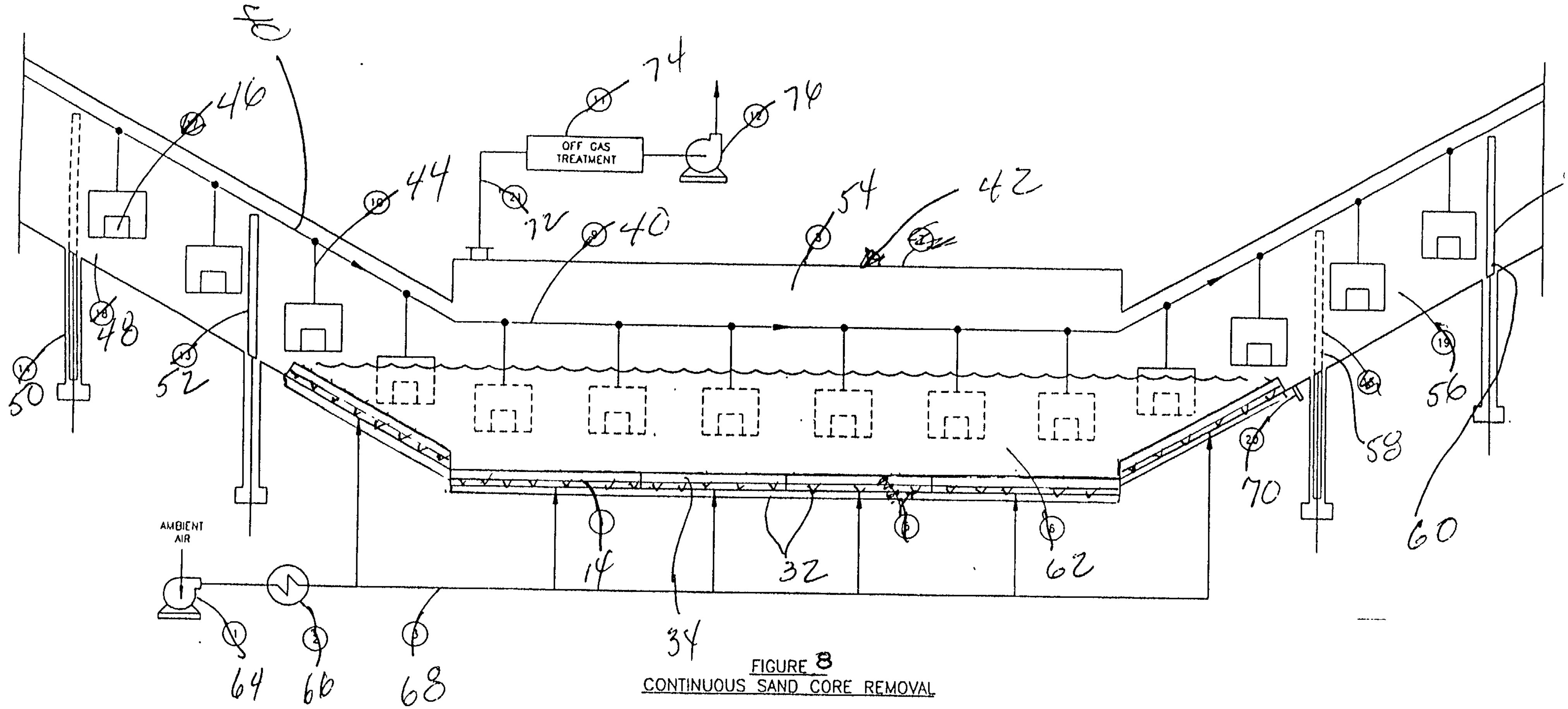

FIGURE 8
CONTINUOUS SAND CORE REMOVAL

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	2453-80A
First Named Inventor	H. Kenneth Staffin
COMPLETE IF KNOWN	
Application Number	/
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"Fluidized Bed Gas Distributor System for Elevated Temperature Operation"

(Title of the Invention)

the specification of which

☒ is attached hereto

OR

☐ was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International Application Number [ ] and was amended on (MM/DD/YYYY) [ ] (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)

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(July 1998)

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DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number →	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number *(if applicable)*

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*

OR

☒ Registered practitioner(s) name/registration number listed below

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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☒ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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DECLARATION

ADDITIONAL INVENTOR(S)
Supplemental Sheet

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Inventor's Signature						Date	
Residence: City		State		Country		Citizenship	
Post Office Address							
Post Office Address							
City		State		ZIP		Country	